

MEAN LAKE LEVELS DURING JANUARY, 1915.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Feb. 4, 1915.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during January, 1915: Above mean sea level at New York.....	Fect. 601.81	Fect. 579.44	Fect. 571.09	Fect. 244.70
Above or below—				
Mean stage of December, 1914.....	-0.27	-0.18	-0.29	-0.13
Mean stage of January, 1914.....	-0.60	-0.63	-0.96	-0.90
Average stage for January, last 10 years.....	-0.22	-0.63	-0.72	-0.97
Highest recorded January stage.....	-0.97	-3.23	-2.46	-2.90
Lowest recorded January stage.....	+0.93	+0.36	+0.13	+0.90
Probable change during February, 1915.....	-0.2	0.0	-0.1	+0.1

THE WATER RESOURCES OF STRAWBERRY CREEK, BERKELEY, CAL.

By WILLIAM G. REED and HOWARD M. LOY.

[Dated: University of California, Dec. 17, 1914.]

Of the problems of immediate practical importance to the State of California at least two—that of frost and that of available water supply—are from their nature largely meteorological. In both these problems the importance of intensive studies of small areas is being recognized more and more as time goes on.

Because of the necessities of the university a study of the water resources of Strawberry Creek, which flows through the campus, has interested the university administration and the College of Civil Engineering. The wide variety of conditions in the drainage area of the creek, together with its small extent, about 1 square mile, also make it an interesting locality for the study of local rainfall variations and raingage exposure. As the flow of the stream is measured by a recording weir, the relation of rainfall to run-off may also be studied from this area. In view of these facts the problem of the water resources of Strawberry Canyon was undertaken as a senior thesis by Mr. Loy, of the College of Civil Engineering of the University of California. Prof. Charles Gilman Hyde had the general direction of the thesis work, and the senior author of this paper assisted in the meteorological aspects of the study. The work done during the year 1913-14 by Mr. Loy is the beginning of a study which it is hoped may be carried on for several years. During the present winter the study is being made by Mr. M. K. White with additional raingages and in the light of the work done in 1913-14.

Topography.—The general topographic features of the drainage area and the positions of the raingages in service may be seen from the map (fig. 1) of this portion of the Berkeley Hills. The character of the soil and the geological structure of the region are such that practically all the water which falls on the drainage area either flows over the wier (*W* in fig. 1) or is evaporated from the drainage area. Strawberry Creek is a torrential stream, its main channel having a grade of about 400 feet to the mile. The drainage area of the creek above the wier is about 600 acres. The portion of the area north of the creek is larger than that south of the creek and the slopes are less steep. The entire area is, however, cut by ravines, so that rain water finds its way into the creek almost immediately. Strawberry Canyon is surrounded by a ridge, or spurs of ridges, varying in altitude from 1,200 to 1,500 feet above sea level. The elevation of Strawberry Creek at the wier is about 500 feet.

Sources.—In the study of the rainfall and run-off, data from the following sources were available:

(1) Rainfall amounts for the 12-hour periods ending at 8 a. m. and 8 p. m., 120th meridian time, on the university campus, from readings of an 8-inch gage 15 feet above the ground, but sheltered from wind by trees at some distance.

(2) Automatic records from a Friez tipping-bucket raingage on the university campus, 60 feet above the ground and not sheltered from the sweep of the wind.

(3) Rainfall amounts from five 8-inch gages exposed on the ground in the drainage area as indicated in figure 1.

(4) Stream-flow records from the recording weir located in the main channel of Strawberry Creek (*W* in fig. 1).

The rainfall records from both gages on the campus are in essential accord in spite of the difference in exposure conditions. The gages exposed on the drainage area were located with the intention of getting exposures at different altitudes more or less uniformly distributed over the area. The locations of the gages are shown by the figures on the accompanying map (fig. 1). Table 1 shows the essential conditions of the exposure of each of the five gages exposed on the drainage area. The position of the gages was somewhat influenced by the necessities of observation; they were so located that it was possible to make the round of the gages after each storm when the ground was in poor condition.

TABLE 1.—Conditions of exposure of field raingages in Strawberry Canyon.

Gage No. ¹	Altitude A. M. S. L.	Angle of slope.		Height of rim above ground.	Exposure.
		Above gage.	Below gage.		
1	Fect. 520	4	28	20	Near creek bed. Well surrounded by vegetation. Near steep south side of canyon.
2	730	18	14	20	Similar to gage No. 1.
3	880	30	22	15	Ridge between two branches of creek. More exposed to wind than gages Nos. 1 and 2.
4	1,225	24	20	15	Shallow depression at head of small tributary.
5	1,270	12	22	15	Dare ridge. Exposed to sweep of the wind.

¹ These numbers correspond to those on the map, fig. 1.

The discharge of the stream is measured by a triangular weir, a form recognized as more accurate for a stream which varies widely, than a rectangular weir. The opening of the weir is V-shaped, with an angle of 90° at the bottom, the sides of the V are angle iron, so that the opening is sharp. The discharge is computed by Thompson's well-known formula

$$Q = 2.64 h^{\frac{5}{2}}$$

where *Q* is the discharge in second-feet and *h* is the head in feet.

The recording device indicates simply the level of the water flowing over the weir. It consists of a pencil attached to a float working in a well beside the weir and recording with a scale of 1:1 on a sheet of paper wrapped around a wooden cylinder which is turned by clockwork at the rate of about $\frac{1}{2}$ inch per hour, making a complete revolution in one week.

Results.—Perhaps the most important result of the study during the year was the recognition of the great difference in the catch of the gages. Probably this difference was due to exposure conditions. While it was, of course, recognized that the catch of the gage was dependent on the exposure, it was hoped that the results at the different gages might give an idea of the precipitation in the immediate vicinity of each gage. Table 2, which presents the records of the gages at the end of each storm,

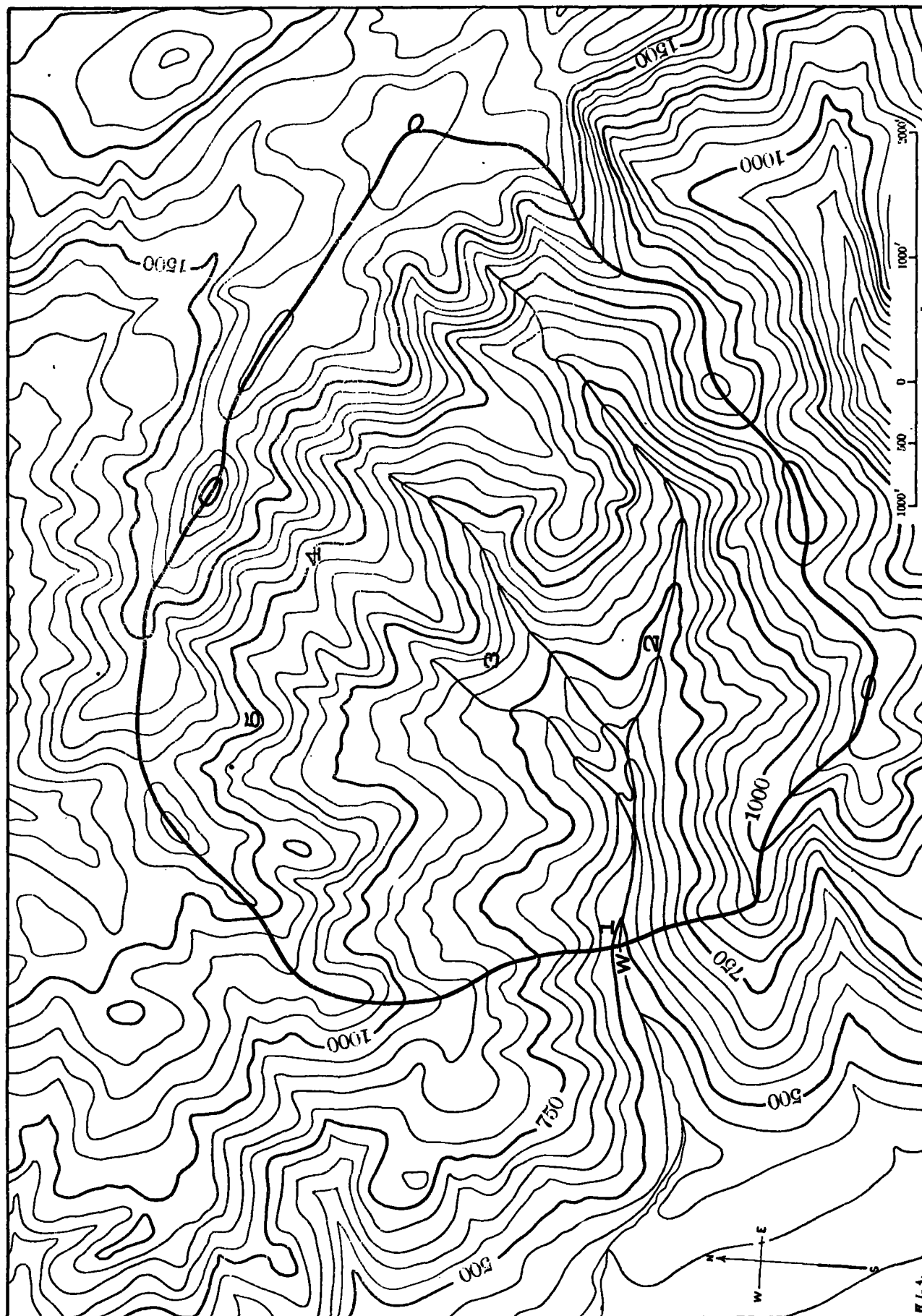


FIG. 1.—Contour map of Strawberry Creek, Berkeley, Cal., by W. H. Otis. Contour interval, 50 feet. Weir located at W; raingages located at points numbered 1, 2, 3, 4, and 5.

shows the great difference in the catch of the different gages. Contrary to the usual condition in California and elsewhere the gages at the higher levels showed a smaller amount of precipitation than those in the bottom of the canyon. It is not yet clear whether the reason for this is to be found in the sheltering trees and bushes which restrict the sweep of the wind, or in the more complicated question of the effective elevation of the raingages.

TABLE 2.—Precipitation, in inches, at Berkeley, Cal., July 1, 1913, to June 30, 1914.

Date.	1913.									
	November.					December.				
	Obs.	C. E.	Field gages.					Obs.	C. E.	Field gages.
			1	2	3	4	5			
1.			0.94	0.95						
2.			0.02	0.02						
3.			0.02	0.02						
4.			0.38	0.30						
5.			0.01	0.02						
6.			0.08	0.08						
7.										
8.										
9.										
10.			0.13	0.11				0.21	(*)	
11.			0.14	0.16				0.03	(*)	
12.			0.35	0.43				0.35	(*)	
13.			0.15	0.11				0.16	(*)	
14.								0.85	0.90	0.72
15.								0.72	0.72	0.52
16.										
17.										
18.										
19.										
20.										
21.										
22.										
23.										
24.										
25.										
26.										
27.										
28.										
29.										
30.										
31.										
Total	0.19	0.30	0.36	5.83	5.82			6.98	8.25	8.45

1914.

Date.	January.						February.							
	Obs.	C. E.	Field gages.					Obs.	C. E.	Field gages.				
			1	2	3	4	5			1	2	3	4	5
1	0.26	(*)												
2	1.02	(*)	1.48	1.61	1.24	1.12	0.62							
3														
4														
5														
6														
7	0.52	(*)												
8			0.00	0.62	0.50	0.56	0.51							
9														
10														
11														
12	2.28	(*)												
13	0.36	(*)												
14	1.46	(*)												
15														
16	T.	(*)	4.37	4.48	3.85	3.30	2.25	0.03	0.02					
17	1.59	(*)						0.08	0.07					
18	0.20	(*)						0.63	0.57					
19	0.18	(*)						0.48	0.49					
20	T.	(*)						1.79	1.74					
21	0.90	(*)						0.38	0.37					
22	1.16	(*)						0.58	0.58					
23	0.41	(*)								4.47	4.56	4.00	3.80	2.92
24	1.32	(*)	6.90	6.98	5.87	5.95	3.10							
25	0.86	(*)						0.01						
26	0.19	(*)												
27	0.03	(*)	1.06	1.14	0.66	0.66	0.41							
28														
29														
30														
31														
Total	12.74		14.15	14.83	12.18	11.68	8.89	3.98	3.84	4.47	4.56	4.00	3.80	2.92

TABLE 2.—Precipitation, in inches, at Berkeley, Cal., July 1, 1913, to June 30, 1914—Continued.

1914—Continued.

Date.	March.						April.						My.	Je.		
	Obs.	E.	Field gages.					Obs.	E.	Field gages.						
			1	2	3	4	5			1	2	3			4	5
1	0.02							0.01								
2		0.02	0.02	0.02	0.02	0.02	0.02									
3																
4																
5								0.58	0.52	0.62	0.67	0.61	0.55	0.36		
6																
7																
8														0.33		
9								0.07	0.07					0.05		
10								0.31	0.30					0.21		
11								0.19	(*)	0.61	0.65	0.59	0.54	0.35		
12																
13																
14																
15																
16																
17																
18																
19																
20																
21																
22								0.06	(*)							
23								0.07	(*)	0.22	0.22	0.19	0.22	0.25		
24														0.08		
25														0.13		
26														0.14-0.01		
27														0.01		
28								0.05	0.04							
29										0.06	0.08	0.07	0.08	0.07		
30																
31																
Total	0.99	1.02	1.00	0.98	0.88	0.87	0.84	1.33		1.51	1.62	1.66	1.39	1.03		
										0.62	0.62	0.62	0.48			

* Recording gage out of order.

Obs.=gage at Students Observatory, read twice daily, 8 a. m. and 8 p. m. P. S. T.

C. E.=Recording gage on roof of Civil Engineering Building.

1=field gage placed Nov. 17; read after each storm.

2=field gage placed Nov. 19; read after each storm.

3=field gage placed Nov. 28; read after each storm.

4=field gage placed Dec. 1; read after each storm.

5=field gage placed Dec. 1; read after each storm.

The winds during precipitation are almost always from the south and the southeast and, therefore, cross the ridge to the south of the canyon. It may well be that the effective height of the gages at the foot of the steep south ridge is the same as that of the ridge; in other words the elevation from which precipitation occurs is that of the crest of the ridge rather than that at which the gages are located. An effort is being made during 1914-15 to obtain rainfall measurements from the crest of this ridge itself to determine, if possible, what the relation is. It will be noted from Table 2 that the precipitation at gage 2 is larger than that at gage 1 and from the map that the portion of the ridge to the south of gage 2 is higher than the portion to the south of gage 1.

The relations between the run-off as measured by the weir and the rainfall as shown by the record from the gage at the Students' Observatory is shown by Table 3. A study of the fragmentary records before 1910 together with the records from the recording weir shows that in seasons with about the average precipitation of 26 inches, the run-off is from 0.25 to 0.31 of the rainfall. For seasons of lighter rainfall the percentage is greatly decreased, thus in 1911-12 and in 1912-13, it is 0.048 and 0.041, respectively. The relation between precipitation and the flow of Strawberry Creek is shown by figure 2, which shows the daily rainfall at Berkeley and the run-off as measured by the recording weir.

The studies made during 1913-14 form the beginning of a series which will increase in usefulness as it becomes more complete. It is hoped that the University of California will be able to continue this intensive study of rainfall and run-off in Strawberry Canyon until the amount of water available and the relation between the precipitation and the stream flow in the east bay region may be determined with accuracy.

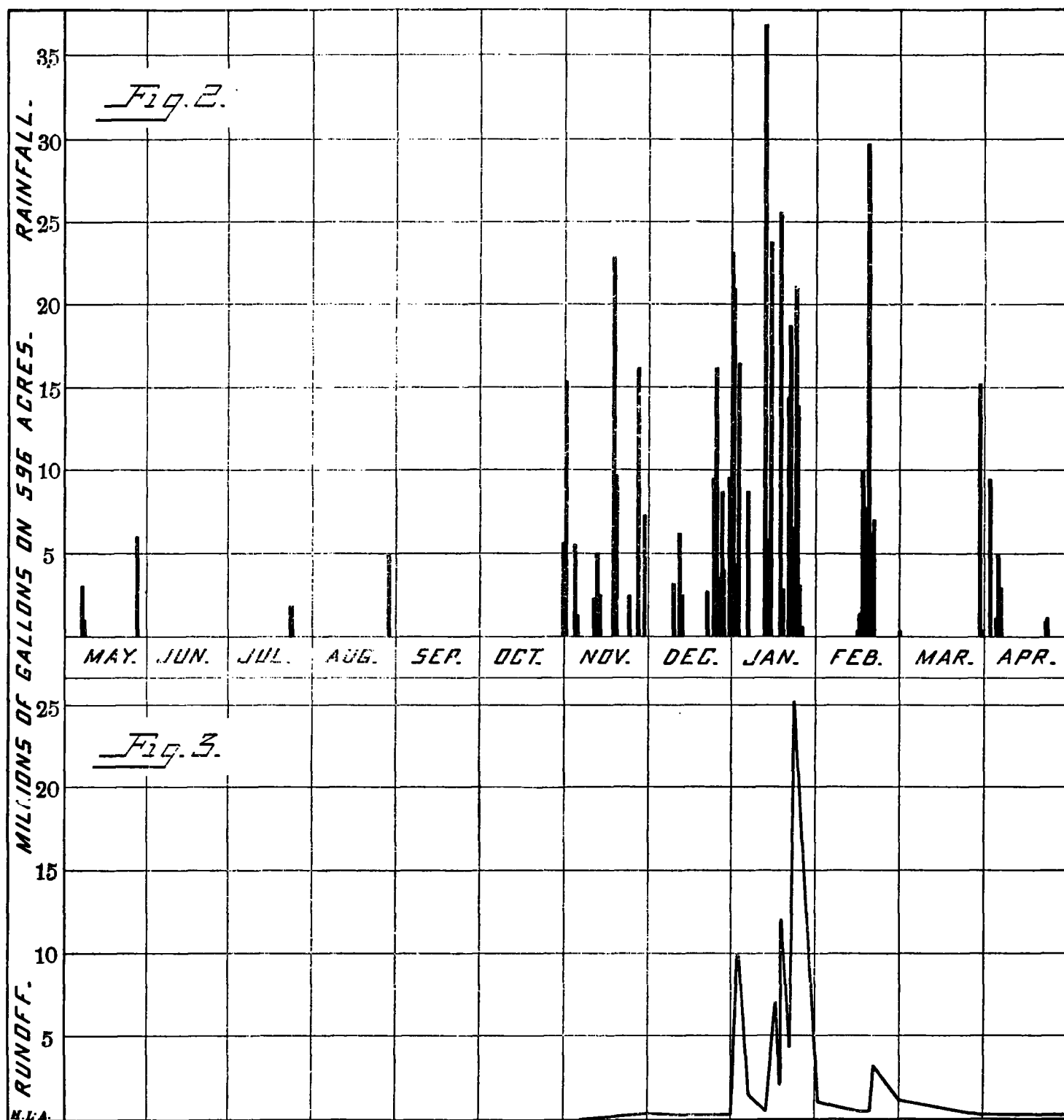


FIG. 2.—Daily rainfalls in gallons over Strawberry Creek basin, Berkeley, Cal., 1913-14.

FIG. 3.—Daily discharges in gallons of Strawberry Creek, Berkeley, Cal., 1913-14, measured by the recording weir.

TABLE 3.—Rainfall and run-off in Strawberry Canyon.

[Millions of gallons.]

Month.	1910-11			1911-12		
	Rainfall.	Run-off.	Ro/Rf.	Rainfall.	Run-off.	Ro/Rf.
July.....	0.00	0.355	.....	T.	1.221	.....
August.....	0.00	0.279	.....	0.00	0.842	.....
September.....	0.971	0.149	0.154	T.	0.430	.....
October.....	9.710	0.256	0.026	11.820	0.712	0.060
November.....	14.109	0.520	0.037	7.445	0.354	0.048
December.....	29.150	0.658	0.023	40.650	0.788	0.019
January.....	258.800	33.636	0.130	59.100	1.892	0.032
February.....	65.600	47.740	0.728	8.750	0.850	0.097
March.....	83.700	52.928	0.534	47.900	2.091	0.044
April.....	25.250	11.991	0.475	23.800	0.784	0.033
May.....	4.370	4.001	0.916	25.250	0.800	0.032
June.....	0.648	2.041	3.145	13.790	0.644	0.047
Season.....	492.209	154.564	0.314	238.495	11.407	0.048

TABLE 3.—Rainfall and run-off in Strawberry Canyon—Continued.

[Millions of gallons.]

Month.	1912-13			1913-14		
	Rainfall.	Run-off.	Ro/Rf.	Rainfall.	Run-off.	Ro/Rf.
July.....	0.324	0.200	0.617	3.000	0.000	.....
August.....	0.000	0.130	.....	4.860	0.000	.....
September.....	23.630	0.150	0.006	0.000	0.000	0.000
October.....	11.340	0.177	0.016	5.830	0.000	.....
November.....	62.800	0.132	0.002	94.400	0.297	0.002
December.....	26.210	1.085	0.042	107.850	15.307	0.142
January.....	61.230	5.617	0.092	193.800	162.178	0.838
February.....	10.370	1.055	0.102	64.000	21.851	0.342
March.....	22.050	1.052	0.033	14.900	11.276	0.753
April.....	9.230	0.602	0.065	23.340	4.489	0.193
May.....	16.030	0.169	0.011	.....	.....	.....
June.....	T.	0.060	.....	.....	.....	.....
Season.....	253.264	10.430	0.041	.....	.....	.....